DERIVATIVE AIRCRAFT AND METHODS FOR THEIR MANUFACTURE

TECHNICAL FIELD

[0001] The following disclosure relates generally to derivative aircraft and, more particularly, to derivative aircraft wing configurations for high-speed aircraft and methods for designing and manufacturing such configurations.

BACKGROUND

[0002] Mission requirements typically dictate the configurations of aircraft. For example, aircraft with long-range mission requirements are typically configured to carry large quantities of fuel to increase their range between fuel stops. In addition, such aircraft are typically configured with relatively large wings to enable them to take off and land on conventional airport runways with heavy fuel loads. In contrast, aircraft with short-range mission requirements do not need to carry large quantities of fuel. Consequently, they typically require less wing area and have lower operating empty weights than long-range aircraft having comparable passenger capacities. As a result, using a long-range aircraft for a short flight can be very inefficient because the unnecessarily high empty weight of the long-range aircraft can result in poor fuel economy.

[0003] Accordingly, it would be advantageous for an aircraft manufacturer to be able to offer a wide range of aircraft configurations, with each configuration being tailored to a particular mission. In this way, customers desiring long-range aircraft could order models having relatively large fuel capacities and large wings, and customers desiring short-range aircraft could order models having relatively small fuel capacities and small wings. In practice, however, the cost associated with designing, manufacturing, and certifying a new aircraft is substantial. As a result,

many aircraft manufacturers offer only a limited range of models that, not surprisingly, represent a compromise of disparate mission requirements.

[0004] One way that aircraft manufacturers try to minimize the high cost associated with developing new aircraft is to develop "derivative" aircraft. Derivative aircraft are "new" aircraft designs derived from existing aircraft designs. By utilizing many of the components and features from the existing aircraft designs, derivative aircraft can greatly reduce the cost of designing, manufacturing, and certifying a new aircraft configuration.

[0005] Figures 1A-C are top views of three derivative aircraft wings 101a-c, respectively, in accordance with the prior art. Each of the derivative aircraft wings 101a-c provides more wing area than an existing wing 102 from which it was derived. For example, the derivative aircraft wing 101a shown in Figure 1A includes the existing wing 102 and a wing-root insert 104a extending between the existing wing 102 and a fuselage 110. The existing wing 102 includes an engine pod 142 and landing gear assembly 108 that are, accordingly, moved away from the fuselage 110 by the wing insert 104a. The derivative aircraft wing 101b shown in Figure 1B includes a chordwise wing insert 104b extending between forward and aft portions of the existing wing 102. The derivative aircraft wing 101c shown in Figure 1C includes a wing-tip extension 104c extending outward from the existing wing 102.

[0006] Each of the derivative aircraft wings 101a-c has shortcomings. For example, the wing-root insert 104a shown in Figure 1A shifts the landing gear assembly 108, the engine pod 142, and other wing systems (e.g., leading edge slats, trailing edge flaps, and spoilers) away from the fuselage 110, thus necessitating, at a minimum, lengthening of the fuel, hydraulic, and electrical lines that extend to these systems from the fuselage 110. In addition, shifting the engine pod 142 further outboard can also require a redesign of the rudder of the baseline aircraft (not shown) to compensate for increased yaw forces resulting from an "engine out" design condition.

[0007] The chordwise insert 104b shown in Figure 1B also has a number of shortcomings. For example, the addition of the chordwise insert 104b may require relofting the entire wing to restore the original airfoil shape of the existing wing 102 to the cross-section. In addition, the existing wing 102 must be reworked along the entire span to integrate the chordwise insert 104b with the existing structure.

[0008] The wing-tip extension 104c shown in Figure 1C also has shortcomings. Although this may be the simplest approach to increasing wing area, the wing-tip extension 104c unfavorably shifts the center of pressure on the wing outboard, thereby increasing the bending loads on the existing wing 102. As a result, adding the wing-tip extension 104c can require structurally reinforcing the existing wing 102, especially at the attachment to the fuselage 110. A further shortcoming associated with the wing-tip extension 104c is that structural reinforcement is often required at the tip of the existing wing 102 to carry the loads introduced from the wing-tip extension 104c. Still further, the wing-tip extension 104c typically does not provide a substantial increase in wing area or fuel volume.

SUMMARY

[0009] The present invention is directed to derivative aircraft and methods for their manufacture. In one embodiment, a derivative wing is derived from a baseline wing having a first outboard wing portion, a first forward inboard wing portion, and a first aft inboard wing portion. In one aspect of this embodiment, the derivative wing includes a second outboard wing portion sized and shaped at least generally similarly to the first outboard wing portion, a second forward inboard wing portion sized and shaped at least generally similarly to the first forward inboard wing portion, and a second aft inboard wing portion sized and shaped at least generally similarly to the first aft inboard wing portion. In another aspect of this embodiment, the derivative wing further includes a wing insert having a spanwise wing insert portion and a chordwise wing insert portion. In this embodiment, the chordwise wing insert portion is interposed between the second forward inboard

wing portion and the second aft inboard wing portion to structurally connect the second forward inboard wing portion to the second aft inboard wing portion. Further, the spanwise wing insert portion is interposed between the second outboard wing portion and the second forward and aft inboard wing portions to structurally connect the second outboard wing portion to the second forward and aft inboard wing portions. Accordingly, in this embodiment, the addition of the wing insert portions provides the derivative wing with a wing area greater than the baseline wing from which it was derived. In other embodiments, wing portions similar to the wing insert portions can be removed from a baseline wing to provide a derivative wing with a wing area less than the baseline wing from which it was derived.

[0010] In another embodiment, a method for manufacturing an aircraft wing includes providing an outboard wing portion, a forward inboard wing portion, and an aft inboard wing portion. In one aspect of this embodiment, the aft inboard wing portion is configured to be attached to the forward inboard wing portion, and the outboard wing portion is configured to be attached to the forward and aft inboard wing portions. In another aspect of this embodiment, the method further includes attaching a chordwise wing insert portion to the forward and aft inboard wing portions, and attaching a spanwise wing insert portion to the outboard wing portion and the forward and aft inboard wing portions.

[0011] In yet another embodiment, a wing insert is usable with a baseline wing having an outboard wing portion and an inboard wing portion, the inboard wing portion having a forward inboard wing portion and an aft inboard wing portion. In one aspect of this embodiment, the wing insert includes a chordwise wing insert portion and a spanwise wing insert portion adjacent to the chordwise wing insert portion. The chordwise wing insert portion is configured to be interposed between the forward inboard wing portion and the aft inboard wing portion to increase an average chord of the inboard wing portion of the baseline wing. The spanwise wing insert portion is configured to be interposed between the outboard wing

portion and the forward and aft inboard wing portions to increase a wingspan of the baseline wing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Figures 1A-C are top views of three derivative aircraft wings in accordance with the prior art.

[0013] Figure 2 is a top-front isometric view of a baseline aircraft having a baseline fuselage and a baseline wing in accordance with an embodiment of the invention.

[0014] Figure 3 is a top-front isometric view of a derivative aircraft having a derivative fuselage and a derivative wing in accordance with an embodiment of the invention.

[0015] Figure 4 is a top view of the baseline wing and a portion of the baseline fuselage shown in Figure 2 in accordance with an embodiment of the invention.

[0016] Figure 5 is a top view of the derivative wing and a portion of the derivative fuselage shown in Figure 3 in accordance with an embodiment of the invention.

[0017] Figures 6A and 6B are top views of a baseline wing and a derivative wing, respectively, in accordance with an embodiment of the invention.

[0018] Figure 7 is a top view of a derivative wing derived from a delta-shaped baseline wing in accordance with an embodiment of the invention.

DETAILED DESCRIPTION

[0019] The following disclosure describes derivative aircraft and derivative aircraft wings. Certain specific details are set forth in the following description and in Figures 2-7 to provide a thorough understanding of various embodiments of the invention. Those of ordinary skill in the relevant art will understand, however, that the present invention may have additional embodiments and that the invention may be practiced without several of the details described below. In other instances, well-known structures and systems often associated with aircraft have

not been shown or described in detail here to avoid unnecessarily obscuring the description of the various embodiments of the invention.

[0020] In the drawings, identical reference numbers identify identical or substantially similar elements. To facilitate the discussion of any particular element, the most significant digit or digits in a reference number refers to the figure number in which that element is first introduced. For example, element 202 is first introduced and discussed in reference to Figure 2. In addition, dimensions, angles, and other specifications shown in the figures are representative of particular embodiments of the invention. Accordingly, other embodiments of the invention can have other dimensions, angles, and specifications without departing from the spirit or scope of the present invention.

[0021] Figure 2 is a top-front isometric view of a baseline aircraft 200 having a baseline fuselage 210 and a baseline wing 202 in accordance with an embodiment of the invention. In one aspect of this embodiment, the baseline fuselage 210 has a forward fuselage portion 212 and an aft fuselage portion 214 providing a baseline fuselage length. In a further aspect of this embodiment, the baseline wing 202 extends outwardly from the baseline fuselage 210 and has an inboard wing portion 204 and an outboard wing portion 206 providing a baseline wing area. The inboard wing portion 204 of the baseline wing 202 has a forward inboard wing portion 207 toward a leading edge 203 and an aft inboard wing portion 208 toward a trailing edge 205.

[0022] Figure 3 is a top-front isometric view of a derivative aircraft 300 having a derivative fuselage 310 and a derivative wing 321 in accordance with an embodiment of the invention. In one aspect of this embodiment, the derivative aircraft 300 is derived from the baseline aircraft 200 shown in Figure 2 and includes many components that are the same or at least substantially similar to components of the baseline aircraft 200. For example, the derivative fuselage 310 includes the forward fuselage portion 212 and the aft fuselage portion 214 of the baseline fuselage 210. Similarly, the derivative wing 321 includes the

outboard wing portion 206, the forward inboard wing portion 207, and the aft inboard wing portion 208 of the baseline wing 202.

[0023] In one embodiment that will be described in greater detail below, the derivative wing 321 further includes a wing insert 323 interposed between the outboard wing portion 206, the forward inboard wing portion 207, and the aft inboard wing portion 208 to structurally connect these wing portions and provide the derivative wing 321 with a wing area greater than the baseline wing area. In one aspect of this embodiment, the derivative fuselage 310 further includes a fuselage insert 312 interposed between the forward fuselage portion 212 and the aft fuselage portion 214 to structurally connect these fuselage portions and provide the derivative fuselage with a fuselage length greater than the baseline fuselage length. Although, in this embodiment, the derivative wing 321 has a wing area greater than the baseline wing 202 from which it is derived, and the derivative fuselage 310 has a fuselage length greater than the baseline fuselage 210 from which it is derived, in other embodiments, other derivative wings can have wing areas less than the baseline wings from which they are derived, and other derivative fuselages can have fuselage lengths less than the baseline fuselages from which they are derived. As will be discussed in greater detail below, reducing wing areas can include removing wing inserts such as the wing insert 323 and rejoining the remaining wing portions, and reducing fuselage lengths can include removing fuselage inserts such as the fuselage insert 312 and rejoining the remaining fuselage portions.

[0024] Returning to Figure 2, in one embodiment the baseline aircraft 200 further includes an empennage 230 extending from the baseline fuselage 210 proximate to the aft fuselage portion 214. In one aspect of this embodiment, the empennage 230 includes a vertical tail 232 and a horizontal tail 234. The vertical tail 232 can include a fixed portion (i.e., a vertical stabilizer) and a moveable portion (i.e., a rudder) for controlling yaw motion of the baseline aircraft 200. Similarly, the horizontal tail 234 can include a fixed portion (i.e., a horizontal stabilizer) and a moveable portion (i.e., an elevator) for controlling pitch motion of the baseline

aircraft 200. In other embodiments, the baseline aircraft 200 can have other control surfaces for controlling pitch and yaw motions.

[0025] In one embodiment, the baseline aircraft 200 further includes a landing gear system 260 and a propulsion system 240. In one aspect of this embodiment, the landing gear system 260 includes a nose gear assembly 261 and a main gear assembly 262, both shown schematically in Figure 2. The nose gear assembly 261 is integrated with the forward fuselage portion 212 and is shown in a stowed configuration in Figure 2. The main gear assembly 262 is integrated with the inboard wing portion 204 and is also shown in a stowed configuration in Figure 2. The landing gear system 260 of the illustrated embodiment represents only one of the many possible landing gear arrangements that can be used in accordance with the present invention. Accordingly, in other embodiments, the baseline aircraft 200 can have other landing gear systems.

[0026] In a further aspect of this embodiment, the propulsion system 240 includes an engine pod 242 suspended from the baseline wing 202 at least proximate to the leading edge 203. In other embodiments, the propulsion system 240 can have other engine configurations. For example, in one embodiment the engine pod 242 can be suspended from the baseline wing 202 proximate to the trailing edge 205. In another embodiment that will be explained in greater detail below, the propulsion system 240 can include two engine pods suspended under each wing for a total of four engine pods. In yet other embodiments, the propulsion system 240 can be mounted to the baseline fuselage 210.

[0027] Figure 4 is a top view of the baseline wing 202 and a portion of the baseline fuselage 210 shown in Figure 2 in accordance with an embodiment of the invention. In one aspect of this embodiment, the baseline wing 202 includes engine support structure 442 structurally attaching the engine pod 242 to the baseline wing 202. The engine support structure 442 is integrated with the forward inboard wing portion 207 at least proximate to the leading edge 203. In a further aspect of this embodiment, the baseline wing 202 includes landing gear support structure 461 structurally attaching the main gear assembly 262 to the

baseline wing 202. The landing gear support structure 461 is integrated with the aft inboard wing portion 208 at least proximate to the trailing edge 205, and it can include a main landing gear beam 464 and a main landing gear trunnion 466. The configuration of the engine support structure 442 and the landing gear support structure 461 shown in Figure 4 represents only one possible configuration. Accordingly, in other embodiments, the engine support structure 442 and the landing gear support structure 461 can have other configurations.

[0028] In another aspect of this embodiment, the baseline wing 202 includes a front spar 452 and a rear spar 454, and the baseline fuselage 210 includes a first fuselage frame 412 and a second fuselage frame 414. The front and rear spars 452 and 454 extend spanwise through the inboard wing portion 204 and the outboard wing portion 206, and the rear spar 454 is positioned forward of the landing gear support structure 461. The first fuselage frame 412 is positioned adjacent to the front spar 452, and a second fuselage frame 414 is similarly positioned adjacent to the rear spar 454. In other embodiments, the baseline wing 202 and the baseline fuselage 210 can have other wing spar and fuselage frame configurations, respectively.

[0029] In a further aspect of this embodiment, the baseline wing 202 includes a plurality of leading edge slats 480 proximate to the leading edge 203, an outboard flap 484 proximate to the trailing edge 205, and a plurality of spoilers 490 positioned on an upper wing surface 426 forward of the outboard flap 484. The leading edge slats 480 and the outboard flap 484 are moveable to enhance low-speed flight characteristics of the baseline aircraft 200. The spoilers 490 are pivotable upwardly relative to the upper wing surface 426 to slow the airspeed of the baseline aircraft 200. In other embodiments, the baseline wing 202 can have other control surfaces in other configurations.

[0030] In one embodiment, deriving the derivative aircraft 300 (Figure 3) from the baseline aircraft 200 (Figure 2) includes defining a chordwise separation line 456, a spanwise separation line 457, and a fuselage separation line 416. The chordwise separation line 456 extends from the leading edge 203 to the trailing

edge 205 and separates the outboard wing portion 206 from the inboard wing portion 204. The spanwise separation line 457 extends from the baseline fuselage 210 to the chordwise separation line 456 and separates the forward inboard wing portion 207 from the aft inboard wing portion 208. The fuselage separation line 416 extends across the width of the baseline fuselage 210, and separates the forward fuselage portion 212 from the aft fuselage portion 214.

[0031] In one aspect of this embodiment, the chordwise separation line 456 is positioned outboard of the engine support structure 442. Accordingly, the engine support structure 442 may require little or no redesign when deriving the derivative wing 321 (Figure 3) from the baseline wing 202. In another aspect of this embodiment, the spanwise separation line 457 is positioned between the engine support structure 442 and the landing gear support structure 461. For example, in one embodiment, the spanwise separation line 457 is positioned proximate to the rear spar 454. Accordingly, the landing gear support structure 461 may require little or no redesign when deriving the derivative wing 321 (Figure 3) from the baseline wing 202. In yet another aspect of this embodiment, the fuselage separation line 416 is positioned to coincide with the spanwise separation line 457. For example, in one embodiment, the fuselage separation line 416 is positioned proximate to the second fuselage frame 414. In other embodiments, the chordwise separation line 456, the spanwise separation line 457, and the fuselage separation line 416 can have other positions.

[0032] Figure 5 is a top view of the derivative wing 321 and a portion of the derivative fuselage 310 in accordance with an embodiment of the invention. In one aspect of this embodiment, the outboard wing portion 206 is offset from the forward and aft inboard wing portions 207 and 208 along the chordwise separation line 456 (Figure 4), and the forward inboard wing portion 207 is offset from the aft inboard wing portion 208 along the spanwise separation line 457 (Figure 4). In one embodiment, the wing insert 323 includes a spanwise wing insert portion 524 (so named because it increases wingspan), and a chordwise wing insert portion 525 (so named because it increases wing chord). The

chordwise wing insert portion 525 is structurally interposed between the forward inboard wing portion 207 and the aft inboard wing portion 208, and the spanwise wing insert portion 524 is structurally interposed between the outboard wing portion 206 and the forward and aft inboard wing portions 207 and 208. Accordingly, the wing insert 323 can add significant wing area to the baseline wing 202 (Figure 4). In one embodiment, the spanwise and chordwise wing insert portions 524 and 525 can be integral portions of the wing insert 323. In another embodiment, the spanwise and chordwise wing insert portions 524 and 525 can be separate wing insert portions.

[0033] In a further aspect of this embodiment, the forward fuselage portion 212 is offset from the aft fuselage portion 214 along the fuselage separation line 416 (Figure 4), and the fuselage insert 312 is structurally interposed between the forward fuselage portion 212 and the aft fuselage portion 214. In one embodiment, the fuselage insert 312 is at least generally aligned with the chordwise wing insert portion 525. In other embodiments, the wing insert 323 and the fuselage insert 312 can have other configurations.

[0034] In one embodiment, the derivative wing 321 includes a fuel volume 570 having an increased fuel capacity adjacent to the spanwise wing insert portion 524 of the wing insert 323. In another embodiment, the derivative wing 321 includes additional leading edge slats 580 adjacent to the spanwise wing insert portion 524 of the wing insert 323 proximate to the leading edge 203. In one aspect of this embodiment, the additional leading edge slats 580 can be substantially similar in structure and function to the leading edge slats 480 of the baseline wing 202. In yet another embodiment, the derivative wing 321 includes a flap extension portion 584 that extends the outboard flap 484 of the baseline wing 202 inboard adjacent to the spanwise wing insert portion 524 proximate to the trailing edge 205. In still another embodiment, the derivative wing 321 further includes additional spoilers 590 that can be substantially similar in structure and function to the spoilers 490 of the baseline wing 202. The additional spoilers 590

extend the row of spoilers 480 of the baseline wing 202 inboard adjacent to the spanwise wing insert portion 524 forward of the flap extension portion 584.

[0035] In one embodiment, the derivative wing 321 has a generally uniformly tapering airfoil cross-section extending between a wing-root 509 and a wing-tip 511. In one aspect of this embodiment, the forward inboard wing portion 207 and the aft inboard wing portion 208 can be relofted to blend with the chordwise wing insert portion 525 and the spanwise wing insert portion 524 to achieve this uniformly tapering airfoil cross-section. The term "relofting," as used here, means modifying a cross-section to achieve a selected profile. In other embodiments, the forward inboard wing portion 207 and the aft inboard wing portion 208 are not relofted when used in conjunction with the wing insert 323. Whether or not the forward inboard wing portion 207 and the aft inboard wing portion 208 are relofted, the outboard wing portion 206 need not be relofted to blend with the wing insert 323.

[0036] The foregoing discussion of the derivative wing 321 in reference to Figure 5 describes only some of the modifications that may be made to various portions of the baseline wing 202 (Figure 4) to define the derivative wing 321. In other embodiments, other modifications can be made or, conversely, some of the modifications described above can be omitted. Furthermore, in other embodiments, other baseline wing configurations may necessitate modifications other than those described above.

[0037] Embodiments of the wing insert 323 and the fuselage insert 312 discussed above in reference to Figures 2-5 can be employed in a number of different manufacturing scenarios. In one embodiment, the wing insert 323 and the fuselage insert 312 can be retrofit to an existing aircraft to increase the wing area and the fuselage length of the aircraft. In another embodiment, the wing insert 323 can be used at the initial manufacturing stage to produce wings with increased area for use with a "standard" or unmodified fuselage. In yet another embodiment, the wing insert 323 and the fuselage insert 312 can be used at the

initial manufacturing stage to produce a new aircraft having increased wing area and increased fuselage length.

[0038] Although the discussion above with reference to Figures 2-5 describes derivative aircraft having wing areas greater than the baseline aircraft from which they are derived, in other embodiments the derivative aircraft can have wing areas less than the baseline aircraft from which they are derived. In these other embodiments, a derivative wing having a reduced wing area is created by essentially reversing the process outlined above with reference to Figures 4 and 5. For example, in one embodiment a derivative wing having a reduced wing area can be derived from a baseline wing by removing a wing insert from the baseline wing generally similar to the wing insert 323 shown in Figure 5. Similarly, a derivative fuselage having a reduced fuselage length can be derived from a baseline fuselage by removing a fuselage insert generally similar to the fuselage insert 312 shown in Figure 5. After removing these wing and fuselage inserts, the remaining portions of the derivative wing and the derivative fuselage are then structurally reconnected to complete the derivative aircraft.

[0039] Figures 6A is a top view of a baseline wing 602, and Figure 6B is a top view of a derivative wing 621 derived from the baseline wing 602, in accordance with another embodiment of the invention. Referring to Figure 6A, in one aspect of this embodiment, the baseline wing 602 includes an outboard wing portion 606 and an inboard wing portion 604. The inboard wing portion 604 includes a forward inboard wing portion 607 toward a leading edge 603, and an aft inboard wing portion 608 toward a trailing edge 605. In another aspect of this embodiment, the baseline wing 602 includes an inboard engine pod 642 and an outboard engine pod 646. Both the inboard engine pod 642 and the outboard engine pod 646 are suspended from the baseline wing 602 at least proximate to the leading edge 603. An engine support structure 644 structurally attaches the outboard engine pod 646 to the baseline wing 602 and is integrated with the forward inboard wing portion 607. In a further aspect of this embodiment, the baseline wing 602 includes landing gear support structure 661 structurally

attaching a main gear assembly 662 (shown schematically in Figure 6A) to the baseline wing 602. The landing gear support structure 661 is integrated with the aft inboard wing portion 608 proximate to the trailing edge 605.

[0040] In one embodiment, deriving the derivative wing 621 (Figure 6B) from the baseline wing 602 includes defining a chordwise separation line 656 separating the outboard wing portion 606 from the inboard wing portion 604, and a spanwise separation line 657 intersecting the chordwise separation line 656 and separating the forward inboard wing portion 607 from the aft inboard wing portion 608. In one aspect of this embodiment, the chordwise separation line 656 is positioned outboard of the engine support structure 644, and the spanwise separation line 657 is positioned between the engine support structure 644 and the landing gear support structure 661. In other embodiments, the chordwise separation line 656 and the spanwise separation line 657 can have other positions. Accordingly, the engine and landing gear support structures 644 and 661, respectively, can undergo little or no redesign when deriving the derivative wing 621 from the baseline wing 602.

[0041] Referring now to Figure 6B the derivative wing 621 can include the outboard wing portion 606, the forward inboard wing portion 607, the aft inboard wing portion 608, and a wing insert 623. The outboard wing portion 606 is offset from the forward and aft inboard wing portions 607 and 608 along the chordwise separation line 656 (Figure 6A), and the forward inboard wing portion 607 is offset from the aft inboard wing portion 608 along the spanwise separation line 651 (Figure 6A). The wing insert 623 includes a chordwise wing insert portion 625 and a spanwise wing insert portion 624. The chordwise wing insert portion 625 is structurally interposed between the forward inboard wing portion 607 and the aft inboard wing portion 608, and the spanwise wing insert portion 624 is structurally interposed between the outboard wing portion 606 and the forward and aft inboard wing portions 607 and 608. Accordingly, the wing insert 623 can significantly increase the wing area of the baseline wing 602.

[0042] Figure 7 is a top view of a derivative wing 721 derived from a delta-shaped baseline wing (not shown) in accordance with an embodiment of the invention. In one aspect of this embodiment, the derivative wing 721 includes a number of components from the delta-shaped baseline wing from which it was derived, such as an outboard wing portion 706, a forward inboard wing portion 707, and an aft inboard wing portion 708. In the illustrated embodiment, the aft inboard wing portion 708 includes an engine nacelle 742 and a main landing gear assembly 762. In a further aspect of this embodiment, the derivative wing 721 includes a wing insert 723 having a spanwise wing insert portion 724 and a chordwise wing insert portion 725. The spanwise wing insert portion 724 structurally connects the outboard wing portion 706 to the forward and aft inboard wing portions 707 and 708 outboard of the engine nacelle 742. Similarly, the chordwise wing insert portion 725 structurally connects the forward inboard wing portion 707 to the aft inboard wing portion 708 forward of the engine nacelle 742 and the landing gear assembly 762. Accordingly, the wing insert 723 can significantly increase the wing area of the delta-shaped wing from which it was derived.

[0043] There are a number of advantages associated with embodiments of the derivative aircraft described above with reference to Figures 2-7. One advantage is the relative ease with which they can be designed and manufactured. This advantage is a direct result of the wing and fuselage insert configurations that increase commonality between the baseline aircraft and the derivative aircraft, enabling the derivative aircraft to utilize many of the components of the baseline aircraft and leverage the design, manufacture, and certification of the baseline aircraft. Although some modification to the flight systems of the baseline aircraft may be required (e.g., lengthening of hydraulic, fuel, and electrical systems), the modification will not entail major structural rework to the airframe of the baseline aircraft. For example, in one embodiment, the wing insert (e.g., wing insert 323 shown in Figure 5) requires little or no structural modification to the engine support structure, the main landing gear support structure, and the outboard portion of the wing.

[0044] Yet another advantage associated with embodiments of the derivative aircraft described above is that they do not require redesign of the yaw control surfaces of the baseline aircraft. This advantage can be understood with reference to Figures 2 and 3 above. Referring to Figure 3, because the spanwise wing insert portion is outboard of the propulsion system 240, and hence does not move the engine pod 242 outboard relative to the fuselage 310, there will be no increase in yaw moment on the derivative aircraft 300 as compared to the baseline aircraft 200 (Figure 2) in a "one engine out" design condition. As a result, the vertical tail 232 of the baseline aircraft 200 does not have to be reconfigured when developing the derivative aircraft 300 from the baseline aircraft 200. Thus, the empennage 230 of the baseline aircraft 200 can remain at least generally, if not entirely, the same as that of the derivative aircraft 300.

[0045] Still another advantage is the relatively small amount of relofting necessitated by the wing inserts. For example, in one embodiment, adding the wing insert does not require that the outboard wing portion be relofted, and requires only minimal relofting for the inboard wing portions.

[0046] Yet another advantage associated with embodiments of the derivative wings is that the wing insert increases the wing cross-section at the wing-root, thereby adding significant load carrying capability to the upper and lower wing skins at the wing-root to further enhance the structural capability of the derivative wing. Such enhanced structural capability is desirable given the fact that the loads experienced by the derivative wing could be greater than those experienced by the baseline wing by virtue of the increased fuel capacity and increased wing area. The foregoing advantages represent only some of the advantages associated with the derivative aircraft and derivative wings described above. Accordingly, wing inserts in accordance with other embodiments can have other advantages.

[0047] From the foregoing, it will be appreciated that specific embodiments of the invention have been described herein for purposes of illustration, but that various modifications may be made without deviating from the spirit and scope of the

invention. Accordingly, the invention is not limited, except as by the appended claims.